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VEHICLE MONITORING RADIO COMMUNICATION SYSTEM

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Equivalents:

Abstract

1452029 Interrogation systems MULLARD Ltd 8 Nov 1974 48561/74 Heading H4L In a vehicle monitoring system, e.g. for keep- ing track of and communicating with buses, there is a main transmitting/receiving station and a number of beacon stations having trans- mission powers such that their transmissions do not overlap, and the vehicles are able to store information transmitted by the beacons and transmit information including the stored information to the main station on request. The system operates in response to control signals from the main station such that beacon stations only transmit when the main station is inactive and vice-versa, and the main and beacon station transmitters transmit in the same carrier channel. In the vehicle, data, which may be from a beacon, is received at 21, demodulated at 23 and passed to a register 27. The beacon data consists of a start code, stored in elements 1-5 of the register, a series of five binary "1"s, stored in elements 6-10 and a code identifying the particular beacon, stored in elements 11-15. The data is clocked into the register using a clock pulse extractor 24, the pulses from which pass via an AND gate 25 which is kept open by the Q output from a bi-stable 55. When the start code is detected by comparator gates 29 and a series of "1"s (indicating a beacon signal) by AND gate 38, gate 34 opens and the content of elements 11-15 (identifying the beacon) of register 27 are fed into elements 11-15 of register 46. In this register, other data can be entered into elements 6-10 via terminals 59 and the terminals 60 are prewired to the vehicle address code. When a subsequent transmission including a start code in elements 1-5 and the vehicle address code in elements 6-10 identify- ing the vehicle, is received from a central station the gates 36, which are prewired to the vehicle address code, deliver a "1", such that AND gate 33 is opened to switch the bi-stable 55, thus cutting off the control pulses for the register 27, starting the timer 39 and opening gate 42. The timer delivers an output for a controlled time, to read-out the contents of register 46 into data modulator 52 and thence to transmitter 53 so that they are transmitted back to the central station. Furthermore, the contents of elements 11-15 of the register 27 are read-out into store 43 so that information/instructions/control signals sent to the vehicle from the central station can be read-out. At a beacon station (Fig. 2, not shown) a similar but simpler arrangement enables a central station transmission identifying all beacons to be received and stored at the beacon, and to cause the beacon transmission code to be clocked out of the register 46 and transmitted to any adjacent vehicles. The central station repetitively sends out beacon transmissions to actuate the beacons periodically, and contains control arrangements to cause it to shut down during beacon transmissions. A computer may control the codes sent out in time elements 6-10 so that all vehicles are polled, whilst periodically all beacons are activated. As well as vehicle location, information relating, e.g. to odometer readings (entered in stages 6-10 of register 46 on the vehicle) can be returned to the master station.

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PATENT SPECIFICATION

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(54) VEHICLE MONITORING RADIO COMMUNICATION SYSTEM

(71) We, MULLARD LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a vehicle monitoring radio communication system including a fixed main radio transmitting-

which causes the transmitter on the bus to transmit, to the main station, the beacon-identifying code.

Such a system is described, for example, in the Paper:— "Automatic Vehicle Monitoring Applied to Bus Operations", by Ansel V. Gould, I.EEE Transactions on Vehicular Technology, Volume VT-22 No. 2. May 1973. In the system described in the Paper, each bus is provided with a timer which denotes the time lapsed in 12-second

ERRATUM

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Page 1, Heading, *below* (52) *insert* (72) Inventor RODNEY WILLIAM GIBSON

THE PATENT OFFICE
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... and is hereinafter referred to us being of the type described.

In a typical system of the type described, each beacon station has a transmission range of about thirty metres and transmits, at regular intervals, coded information which identifies the beacon concerned. The beacons may be located, for example, at intervals of a few thousand metres along a fixed route such as a bus route. When a bus moving along the route moves into the region covered by the transmission from a particular beacon, receiving means on the bus receives and stores the coded information which identifies the beacon station concerned. Subsequently, the main station transmits information to the bus

the radio transmitter at the main station and a different channel is used for the beacon station transmitters (for example in the 450 MHz and 150 MHz Bands respectively) and, as a result, two separate receiving systems are required on each vehicle.

By this means, each vehicle can receive information from the master station and from a beacon station simultaneously.

The present invention stems from the realisation of the fact that it is not necessary to be able to receive both transmissions simultaneously and that considerable advantage can be gained if this is not, in fact, the case.

According to the present invention, there is provided a vehicle monitoring radio

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This invention relates to a vehicle monitoring radio communication system including a fixed main radio transmitting-receiving station, a plurality of fixed beacon radio transmitting stations located in the radio transmission area covered by the main station, each beacon station being so located in the said area and having such a transmission power that the region covered by its transmission does not overlap the transmission region of any other beacon station of the system. Such a system typically includes at least one vehicle provided with receiving apparatus for receiving information transmitted by the main station, with receiving apparatus for receiving information transmitted from the beacon stations, with a store for storing information received from any beacon station, and with a radio transmitter for transmitting, on request by the main station, information including stored information received from any beacon station.

Such a system is known and is hereinafter referred to as being of the type described.

In a typical system of the type described, each beacon station has a transmission range of about thirty metres and transmits, at regular intervals, coded information which identifies the beacon concerned. The beacons may be located, for example, at intervals of a few thousand metres along a fixed route such as a bus route. When a bus moving along the route moves into the region covered by the transmission from a particular beacon, receiving means on the bus receives and stores the coded information which identifies the beacon station concerned. Subsequently, the main station transmits information to the bus which causes the transmitter on the bus to transmit, to the main station, the beacon-identifying code.

Such a system is described, for example, in the Paper:— "Automatic Vehicle Monitoring Applied to Bus Operations", by Ansel V. Gould, I.EEE Transactions on Vehicular Technology, Volume VT-22 No. 2. May 1973. In the system described in the Paper, each bus is provided with a timer which denotes the time lapsed, in 12-second units, since the bus passed the beacon station. At regular intervals, the main station transmits coded information which contains a code unique to the bus concerned. Receiving means on the bus receives this information, recognizes its own identity code and, as a result, automatically causes the beacon identity code and the time lapse to be transmitted back to the main station where the information is processed by a computer. An average speed (for example 80 metres per 12 seconds) is assumed for all buses on the route and, since the received information gives the number of 12-second units lapsed since passing a known location (the beacon station) and since the direction of travel of the bus is known, the approximate position of the bus along the route can be computed.

In known systems of the type described, one carrier transmission channel is used for the radio transmitter at the main station and a different channel is used for the beacon station transmitters (for example in the 450 MHz and 150 MHz Bands respectively) and, as a result, two separate receiving systems are required on each vehicle.

By this means, each vehicle can receive information from the master station and from a beacon station simultaneously.

The present invention stems from the realisation of the fact that it is not necessary to be able to receive both transmissions simultaneously and that considerable advantage can be gained if this is not, in fact, the case.

According to the present invention, there is provided a vehicle monitoring radio

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communication system including a fixed main radio transmitting/receiving station, a plurality of fixed beacon radio transmitting stations located in the transmission area covered by the main station, each beacon station being so located in said area and having such a transmission power that the region covered by its transmission does not overlap the transmission region of any other beacon station of the system; and at least one vehicle provided with radio-receiving apparatus for receiving information transmitted by the main and beacon stations, with a store for storing information received from any beacon station, and with a radio transmitter for transmitting, on request by the main station, information including stored information received from any beacon station; wherein the system further includes control means operative such that the beacon stations transmit only during non-transmission periods of the main station and vice versa, and wherein the main and beacon station transmitters are arranged to transmit in the same carrier channel.

Since, in a system according to the invention, the main station and the beacon stations cannot transmit simultaneously, the carrier frequency restrictions no longer apply, with the result that the main station and the beacon stations can all use the same carrier channel; so allowing the same receiving means on each vehicle to be used for receiving all transmissions. The cost of such a system is very considerably less than that of the previously-known systems which use two receiving means (including separate aerials) on each vehicle.

The features and advantages of the invention will be apparent from the following description of an embodiment thereof, taken by way of example, in conjuction with the accompanying drawings, of which:—

Figure 1 is a block schematic circuit diagram of vehicle-mounted apparatus forming part of the present invention.

Figure 2 is a block schematic circuit diagram of apparatus at a beacon station forming part of the present invention, and

Figure 3 is a time chart showing the transmitting sequence of the main station, beacon station, and vehicle transmitters.

Referring now to Figure 1, the apparatus includes a radio receiver 21 having a receiving aerial 22 for reception of radio signals from the main station and from beacon stations. The signal output of receiver 21 is fed to a data demodulator 23 which converts the signal from receiver 21 into a stream of data bits. In the example chosen, it is assumed that each received sequence comprises a stream of fifteen bits. A clock pulse extractor 24 derives clock pulses in well known manner from the data stream and supplied the resultant clock pulses to an AND-gate 25 via lead 26. The fifteen data bits 1 to 15 are fed serially into a shift register 27 via lead 28, under the control of clock pulses from the output of AND-gate 25, and occupy the positions 1 to 15 shown in the fifteen stages of shift register 27. Data bits 1 to 5 are assumed to constitute a start code and are compared in a series of comparator gates 29 with a start code pre-wired to terminals 31. The gates 29 may, for example, comprise five EXCLUSIVE-NOR gates each having one input from a respective stage of register 27 and the other input from a respective one of terminals 31. The output of each EXCLUSIVE-NOR gate is connected to a respective input of an AND-gate the output of which is fed to output lead 32. Thus, in binary logic parlance, the signal on lead 32 is a "one" if the five bits in stages 1 to 5 of shift register 27 correspond with the respective five bits in the start code appearing on terminals 31. If the comparison shows any difference between the two sets of five bits then the signal on lead 32 is a "zero". Lead 32 is connected to respective inputs of AND-gates 33 and 34.

A further series of comparator gates 35, identical with those described with reference to gates 29, compare the five-bit code in stages 6 to 10 of register 27 with a five-bit code appearing on terminals 36. If the 5-bit codes appearing in stages 5 to 10 of register 27 and on terminals 36 are identical, a "one" appears on output lead 37 of gates 35. If they are not identical, a "zero" is given on lead 37.

The data bits appearing in stages 11 to 15 of shift register 27 are assumed to be a message code. Data bits 6 to 10 are also sensed by an AND-gate 38, the output of which is connected via lead 40 to an input of a gate 34, to the inhibit input of a timer unit 39, and to an inverter 41 the output of which is connected to one input of an AND-gate 42. The output of AND-gate 42 is connected to the strobe input of a storage register 43 of the type which, on receiving a strobe signal from AND-gate 42, stores the data bits respectively appearing in stages 11 to 15 of register 27. Each stage of register 43 is connected to a corresponding stage of a binary-to-decimal decoder 44 which then provides an alpha-numeric display on display 45.

It is to be understood that the number of stages shown in the various portions of register 27 have been chosen purely for diagrammatic convenience and may be any appropriate number. Typically, the start code portion (stages 1—5), the status/address code portion (stages 6—10) and the message content portion (stages 11

to 15) would, together with register 43, each comprise eight stages. In this event, decoder 44 might comprise, for example, two 4-bit seven-segment decoders such as Type FJB9357 available from Mullard Limited.

Stages 11 to 15 of register 27 are also connected, via a set of terminals 58, to respective inputs of a storage register 46 of the type whose contents can be read out serially under the control of the shift pulses on output lead 51 of timer unit 39 without destroying the stored contents, and which on receipt of a strobe pulse on output lead 47 of gate 34, destroys the existing contents and stores the data signals present on terminals 58, 59 and 60. Terminals 60 are pre-wired to the address code of the vehicle concerned, i.e. they may be connected to respective terminals 36. Terminals 59 are used for applying various "status" codes, discussed later.

By applying at least fifteen shift pulses to lead 51 (the actual number being determined by timer unit 39), the content of register 46 may be transmitted to the main station.

The output of gate 33 is connected to the set input S of a set-reset flip-flop 55 having complementary signal outputs on outputs Q and $\overline{Q}$ and a reset input R connected to an output of unit 39 via lead 56. The Q output of flip-flop 55 is connected to one input of gate 42 and to the "start" input of unit 39. The $\overline{Q}$ output is connected to a further input of gate 25. A shift pulse generator 57 supplied shift pulses to lead 51 under the control of timer unit 39.

The operation of the circuit shown in Figure 1 will now be described in detail.

It will first be assumed that a transmission from a beacon station is received, the transmission comprising a 15-bit data stream of which bits 1 to 5 comprise a start code common to all vehicles, bits 5—10 are all "ones" to denote a beacon station transmission, and bits 11—15 comprise a beacon identity code unique to the beacon station whose transmission is being received. In the normal (idle) state of the apparatus, flip-flop 55 is reset; so that its Q output thereof is a "zero" and the $\overline{Q}$ output is a "one". Gate 25 is therefore enabled.

The incoming radio signal is received by receiver 21 via aerial 22, the 15-bit data stream being derived from the signal by data demodulator 23 and passed to register 27. Clock pulses at the incoming bit rate are derived from the signal by clock pulse extractor 24 and passed to register 27 via lead 26 and the enabled gate 25. In this way, the 15 bits of the data stream are clocked into register 27 to occupy the correspondingly-numbered stages thereof. The first five bits (1—5) are the start code common to all vehicles and should therefore correspond with the start code pre-wired on terminals 31. Comparator gates 29 thus give a "one" output on lead 32 the instant the 15 bits occupy their respective positions in the register and, hence, gate 34 is enabled via lead 32. Since bits 6 to 10 are each "one", gate 38 provides a "one" on lead 40 and hence gate 34 provides a "one" on lead 47. Bits 11—15 of the received data stream constitute the beacon station identity code and the "one" on lead 47 strobes this code into register 46. The "one" on lead 40 inhibits the operation of timer unit 39 with the result that no shift pulses are fed to register 46 via lead 51. Since bits 6—10 in register 27 are all "ones"—which code does not constitute a vehicle address code, the signal on lead 37 is a "zero" and gate 33 is therefore inhibited and flip-flop 55 cannot be set. Further, the "one" on lead 40 is inverted to "zero" by inverter 41 and the resultant "zero" output of gate 42 prevents the contents of stages 11—15 of register 27 being strobed into register 43.

Summarising the operation so far, a transmission from a beacon station has been received and recognised (by the "all ones" code of bits 6—10), and the identity code of the beacon concerned is now stored in stages 11—15 of register 46. Due to the strobe signal on lead 47, the vehicle identity code is stored in stages 1—5 of register 46 and a "status" code is stored in stages 6—10. The strobing of information into registers 43 and 46 is only effected by the leading edge of the strobe pulse and the stored information cannot be changed until a further leading edge occurs.

The transfer of information into register 46 occurs in less than one bit time and starts at the instant the start code is shifted into states 1—5 of register 27. Thus it is of no significance whether or not a further clock pulse is fed to register 27 via gate 25 since the information in register 46 cannot be changed thereby and since any subsequently-received data stream will in any case clear register 27 whilst shifting in the new stream.

The nature of the beacon station transmission system will be referred to hereinafter but, for the moment, it is assumed that the same data stream is repeatedly transmitted at intervals of, for example, a few seconds. Thus, as soon as a vehicle enters the transmission region covered by a beacon station, the identity code of that station is entered and stored in register 46. So long as the vehicle remains in that region, the same identity code is repeatedly re-entered in register 46. When the vehicle leaves that region, the identity code remains stored in register 46, until the

vehicle enters the transmission region of a further beacon station, whereupon the beacon identity code stored in register 46 is updated, in the manner described above, to that of the new beacon station. Thus, at any instant, register 46 contains information as to the particular beacon last passed by the vehicle.

The main station periodically "interrogates" the vehicle, at instants when no beacon station is transmitting but on the same carrier frequency as that of the beacons, to cause the vehicle apparatus to transmit the stored beacon station identity code back to the main station. A message may be included for display to the driver and other information may be automatically transmitted back to the main station. Such other information may, for example, be the vehicle status, such as "available", "on watch", "not operations", the current fare stage of a bus, number of passengers on board, odometer reading, etc. Such status codes are connected to terminals 59 either by the driver or automatically.

The digital stream transmitted by the main station to all vehicles comprises, in the present embodiment, a start code (bits 1—5), the identity code (bits 6—10) of the particular vehicle for whom the message is intended, and, perhaps, a message code (bits 11—15).

It will first be assumed that the transmitted message is intended for some other vehicle. In this case, the start code is recognised by the unwanted vehicle, but the vehicle address code does not correspond with that which is pre-wired on terminals 36 of the unwanted vehicle. Thus leads 32 and 37 have a "one" and a "zero" signal respectively and gate 33 is inhibited. Flip-flop 55 therefore remains in the reset state with a "zero" on its Q output and gate 42 is inhibited irrespective of the state of gate 38. Therefore the received message bits in stages 11 to 15 of register 27 cannot be stored in register 43 or 46. Thus a transmission from the main station is, in effect, ignored by all vehicles other than the particular one for whom the message is intended.

If the vehicle address code in register stages 6—10 is identical with the code pre-wired on terminals 36, the signal on lead 37 goes to "one". Since the start code has also been recognised (a "one" on lead 32), the output of gate 33 sets flip-flop 55 and the Q and $\overline{Q}$ outputs thereof go to "one" and "zero" respectively. The "zero" on the $\overline{Q}$ output inhibits gate 25 and so prevents any further shift pulses reaching register 27. The 15 bit received data stream is thus temporarily stored in register 27. The "one" on the Q output of flip-flop 55 provides a start signal to unit 39 and also enables gate 42. Since the bits in stages 6—10 are not all "ones", gate 38 is inhibited. Gate 34 is therefore inhibited and gate 42 has a "one" on each input. The resultant "one" output signal of gate 42 therefore strobes message bits 11—15 into register 43, these bits being decoded into alpha-numeric form in decoder 44 and, subject to the bits forming a valid message code, displayed on the display 45 which is so located as to be readily visible by the driver of the vehicle. The displayed message typically comprises two alpha-numeric characters the significance of which are known to the driver. Thus "10" may mean "return to depot", "20" may mean "reduce speed", "24" may mean "call main station on voice channel" and so on. The message bits may, of course, be used either additionally or alternatively to cause an automatic operation within the vehicle, such as imposing an automatic upper speed limit or automatically switching on the interior lights. The method by which such automatic controls can be effected as a result of a particular received signal are well-known to those skilled in the art and will not be further described herein as they are not further relevant to the invention.

The "one" on the Q output of flip-flop 55 starts timer unit 39, which unit then connects shift pulses from pulse generator 57 to register 46 for a period determined by a time circuit in the unit. The timing period is arranged to be just sufficient for all the data bits stored in register 46 to be transmitted serially from the register under control of the shift pulses. At the end of the timing period, the shift pulses on lead 51 are discontinued and a "one" is provided on lead 56 to reset flip-flop 55. The resultant "zero" on the Q output of flip-flop 55 inhibits the unit 39 and resets the timing circuit; the apparatus now being ready to receive the next transmission. The timing circuit of unit 39 may, for example, be a monostable "one-shot" flip-flop or may be a counter which counts the pulses from generator 57 and resets when it has counted sufficient pulses for all the stored bits to have been shifted out of register 46; the resetting of the counter also causing the pulses on lead 51 to be discontinued. Thus the data bits in register 46 are fed serially to data modulator 52 and thence to transmitter 53.

The transmitted data is received at the main station and passed to a computer which decodes the information and provides an appropriate display.

Since the vehicle apparatus largely uses digital techniques, there are, of course, many alternative circuit methods for

producing the desired results, which methods will be apparent to those versed in the art.

Group call facilities may, for example, readily be provided by means of which the main station can cause the same display to be given on display 45 in all vehicles. In this case, a group call code is transmitted by the main station instead of the individual vehicle address code appearing in stages 6 to 10 of register 27. In this case, a further set of comparator gates and terminals, of the type described in relation to gates 35 and terminals 36, is provided; the comparator gates being connected to stages 6—10 of register 27 in parallel with gates 35 and having an output connected to gate 33 in parallel with lead 37. In this way, the apparatus behaves in exactly the same manner as that described with respect to Figure 1 except that all the vehicles display the message in unison. The output of the further set of comparator gates is further connected to the inhibit input of unit 39 in order to prevent the vehicles transmitting back to the main station in response to a group call.

Stages 6—10 of register 46 can be used for storing various messages for transmission back to the main station, such as vehicle status referred to above. In this case, the driver of the vehicle operates an appropriate key on a keyboard on the dashboard of the vehicle and the appropriate status code is automatically established on terminals 59 and, hence, stored in register 46. Many fare-paying public service vehicles are equipped with a driver-operated device which registers the fare stage number applicable at any moment. Such a device is used on such vehicles, for example, provided with a coin-operated ticket dispenser so that each ticket has the appropriate fare stage number printed on it automatically. The fare stage number could be stored in register 46 via terminals 59 for transmission to the main station. In a preferred embodiment, a code denoting the current reading of the vehicle odometer is stored in register 46, either additionally or alternatively to the other information referred to above. This has particular advantage since it provides additional vehicle location information to the main station. Thus, if for example, the odometer is zeroed when the vehicle leaves a predetermined location such as a bus depot, then information regarding the distance travelled since leaving the depot is immediately available and can be used, in conjunction with the stored beacon station information, to compute the distance of the vehicle from the last beacon station passed. This, of course, can give more accurate information concerning the vehicle location than that provided by the time lapse information method used in the known system previously referred to, since grave errors are produced in the latter system if the vehicle is unduly delayed for any reason; for example by traffic congestion or by breakdown of the vehicle concerned.

Odometer readings may, for example, be stored in register 46 in the following manner. The vehicle odometer is arranged to provide an output pulse every 100 metres of travel, e.g. from a contact arrangement on the 1 Km decimal wheel of the odometer, and the odometer pulses are used to drive a binary counter. The binary counter stages are respectively connected to appropriate stages of register 46 used for recording the odometer reading with the result that the counter code is transferred to the register stages each time a main station transmission is received. The odometer code is thus transmitted along with the beacon station code in the manner described above. The binary counter may be provided with a reset input connected to the output of gate 34 so that the counter is reset to zero on receipt of every beacon station transmission. Thus so long as a vehicle is within the transmission range of a beacon station, the odometer code remains substantially at zero. As soon as the vehicle passes out of range of the beacon station, the odometer code denotes the distance travelled from the periphery of the beacon station range. Thus the information transmitted back to the main station on receipt of a call therefrom contains the identity of the beacon station and the distance travelled from the transmission range of that beacon station. If it be assumed that the transmission range of each beacon station is 30 metres for example, then the odometer counter may be arranged to be reset to a code representing 30 metres instead of to zero. This provides greater accuracy of measured distance travelled between beacon stations. Instead of deriving pulses from the vehicle odometer, the pulses may be derived from an axle revolution counter. Such devices are well known to those versed in the art. In a further alternative method, the odometer counter of each vehicle is not reset at each beacon but the software of the main station is so arranged that the necessary calculations are effected by the computer.

Register 46 may further be used to store an emergency code signifying "I am being attacked", for example: this code being transferred to the register on the operation by the driver of a foot-operated switch. Separate register stages may be provided for this purpose, of course, but use is

preferably made of stages normally used for the status code, the address code, or the beacon code. This emergency code is identified at the main station and the appropriate alarm is given.

Summarising the operation of the apparatus shown in Figure 1, an identity code for the last beacon station passed by the vehicle is stored in a register. In response to an interrogation transmission to the vehicle from the main station, the identity code is automatically transmitted together with other information such as the odometer code that may be applicable to the particular system, from the vehicle to the main station. Since, in the system described, only one vehicle can transmit at any one time, all vehicles can use the same transmission carrier frequency and hence, the identical equipment can be used in all vehicles: only the vehicle identity code wiring to terminals 36 and 60 being different for each vehicle.

This invention may be used with any of the usual radio channel operating systems, e.g. single frequency simplex, two frequency simplex, two frequency semi duplex, full duplex, etc. Figure 3 shows a typical system timing diagram applicable to the single frequency simplex mode. Time is divided up into hypothetical slots, each slot being long enough for one transmission to a vehicle and its reply. In the first part of each slot the main transmitter broadcasts a signal either to one of the vehicles or to the beacons. In the second half of each slot either the vehicle just called replies, or, if the beacons have been called, all beacons transmit their respectively individual codes.

In a semi duplex system the base station is capable of receiving and transmitting simultaneously. This is a common mode of working in the United Kingdom where two frequencies are often used—one for signals transmitted to the vehicles and a second frequency for signals received from the vehicles. In this case the length of the time slots can be halved since the base station can call another vehicle while listening to the reply of the one previously called. When the main transmitter calls the beacons to activate them, the main transmitter remains silent for the next time slot so as not to interfere with the beacon transmission which are on the same frequency as the main station transmitter. In the vehicles, which in a semi-duplex system cannot receive and transmit simultaneously, the set must be switched from receive to transmit when it is to reply to a call. In practice, this is achieved by flip-flop 55 of Figure 1 such that, in the normal (idle) state of the apparatus, flip-flop 55 is reset with the result that receiver 21 is operative and the transmitter 53 is inhibited. If a transmission is received from the main station, flip-flop 55 is set as soon as the data bits are stored in register 27 and the receiver 21 is thereby immediately inhibited and the transmitter 53 is made operative so that the reply transmission can be made. If the received transmission is from a beacon station, of course, flip-flop 55 is not set and so the receiver remains operative.

A typical duration of each time slot is 50 mS of which the first 20 mS are occupied by the main station transmission. This leaves 30 mS for receiving the reply from the vehicle after which the next vehicle on the list is called. Thus the vehicles are automatically polled at a rate of twenty per second. Periodically, for example at two-second intervals and hence every 40th time slot, a time slot is left free for the beacon stations to transmit. All the beacon stations are synchronized with the main station time slots by transmitter control means at the main station. Various methods are known for achieving synchronisation between transmitter stations, the most widely-used method being to use a radio channel between the main and beacon stations and to transmit periodic synchronizing signals. This method is sufficiently widely known to merit no further description herein. On receipt of each synchronizing signal, the beacon stations of a system according to the invention immediately respond by transmitting their respective information signals.

An embodiment of suitable beacon apparatus is shown in Figure 2. It will be seen that Figure 2 is very similar to Figure 1; the difference being that some items have been omitted since they are not relevant to the beacon stations. Corresponding items in Figures 1 and 2 have the same reference numerals and the operation of Figure 2 is the same as that of the relevant portion of Figure 1 already described.

With the apparatus shown in Figure 2, it is assumed that the main station, in each beacon station time slot, transmits a 10-bit data stream the first five bits of which constitute a start code and the second five bits of which are a beacon station address code common to all beacons. The beacon station start code is pre-wired on terminals 31 and the beacon station address code is connected to terminals 36. The beacon station identity code, identifying the particular beacon station concerned, is pre-wired on terminals 58, a "one" is pre-wired to each of terminals 59, and the start code is pre-wired to terminals 60. It will thus be appreciated that register 46 contains the data stream referred to in the description of the reception by the vehicle apparatus of a beacon station transmission.

The 10-bit data stream transmitted by the main station is clocked into register 27 in the manner described with reference to Figure 1. The start and address codes are detected by gates 29 and 35 respectively and, hence, leads 32 and 37 each have a "one" signal. Gate 33 therefore sets flip-flop 55 and the stored contents of register 46 are transmitted in the manner described with reference to Figure 1, whereafter flip-flop 55 is reset via lead 56 at the end of the timing period of timer unit 39. Each storage stage of register 46 always contains the same data bit; so there is no technical need to strobe to bits into the register by means of a strobe pulse on lead 47 and the register need only be a read-only wired memory-formed, for example, from a 3-by-5 multiplexer which consecutively selects each of the terminals in groups 60, 59 and 58 under control of the shift pulses. If register 46 is of the same type as that used in the vehicle apparatus, then the connections between terminals 58, 59, 60 and the respective storage stages can be arranged to bypass the respective strobing circuit.

Since the number of beacon stations in any system is usually small compared with the number of vehicles, there may be considerable cost advantage if the beacon station apparatus is the same as the vehicle station apparatus; the items not used in the former being disconnected during installation. In this event, it would be cheaper to provide a strobe pulse on lead 47 than to alter register 46 and such a strobe pulse can readily be provided, for example, by connecting lead 47 to the output of gate 33 or to either of leads 29 or 37. If items 34, 38, 41, 42, 43 and 44 of Figure 1 are constructed as a plug-in unit, for example, an integrated circuit block, then the apparatus may be converted for beacon station use merely by removing the plug-in unit and plugging in a simple unit which connects leads 32 and 47.

The circuit of Figure 1 may be adapted in alternative ways to make it suitable for beacon station use, of course.

In order to enable the transmission range of each beacon station to be adjusted to the range required at its particular location, and to cater for various terrain conditions, the output power of transmitter 53 (typically 250 mW) is made adjustable.

The main station apparatus comprises means for transmitting data streams to the vehicles and beacons, means for receiving data streams from the vehicles, and transmission control means which causes the main station transmitter to shut down whilst the beacon stations are transmitting. A computer is used to cause each vehicle to be polled in turn and to provide the periodic transmissions to the beacon stations. The information received back from each vehicle is stored in the computer which then provides a display on a control console. If the received information contains an odometer reading in addition to the beacon station code, the computer calculates the position of the vehicle and may, for example, cause a point to be illuminated, corresponding to the position of the vehicle, on a map display. A general survey of the various facilities provided by known main station apparatus, and of the computer programmes concerned, is given in the aforementioned Paper by Gould and needs no further description herein since the method of, and apparatus used for, implementing such a system will be clear to those skilled in the art. A chart showing the computer-controlled operating sequence of the transmitters with respect to time t is shown in Figure 3. Each time slot shown may have a duration of, for example, 50 mS and each of the transmission periods, shown as cross-hatched blocks, may have a duration of 20 mS. In the first 20 mS of time slot 1, the main transmitter transmits a stream of data bits containing the vehicle start code, the address code of vehicle 1, and a message code. This automatically causes the transmitter of vehicle 1 to transmit a reply, the reply transmission being completed before the end of time slot 1. The computer at the main station generates the transmitted data stream on an automatic programme basis and stores the reply data stream for computation and/or display purposes.

The process is then repeated in time slot 2 for vehicle number 2 using the latter's address code; and so on up to and including vehicle number 39. It is assumed that every fortieth time slot is reserved for a beacon transmission and, in time slot 40, the main station transmits the beacon start and address codes. All the beacons then transmit their beacon identity codes in time slot 40. In time slot 41, information is transmitted to and received from vehicle 40; and so on. As can be seen from Figure 3, due to the transmission control by the computer the main and beacon stations can never transmit at the same time, with the result that each can transmit to the vehicles in the same carrier channel. In order to avoid the possibility of any interference between the carrier frequencies of the main and beacon station transmitters received by the vehicles, the main station carrier is switched off for the remainder of each time slot in which it transmits to the beacon stations.

The main station transmitter arrangement includes apparatus corresponding to register 46, data modulator 52, and transmitter 53 of Figure

1. The appropriate start and address codes, together with a message code where applicable, are strobed into the register from the computer and are then shifted serially into the data modulator under the control of clock pulses derived (usually by division) from the computer clock pulse generator. The main station receiver arrangement includes apparatus corresponding to receiver 21, data demodulator 23, clock pulse extractor 24, and register 27. As soon as the vehicle identity code is recognised, e.g. by comparator gates such as 29 of Figure 1, in the first five stages of the register as being the same as that just transmitted by the main station transmitter, the computer immediately stores the received information for computation and display purposes. In the case of the periodic transmission to beacon stations, of course, no reply is received because, by the very nature of the system, the main station is beyond the transmission range of any beacon station.

As stated above with reference to Figure 1, the number of bits used for each code, and hence the total number of stages in the register, may vary from system in system; though in general eight bit codes are used. The number of bits used is frequently increased to provide error checking facilities. In the system described in the Paper by Gould, for example, 100% redundancy is used for error checking purposes. Further, the information content of the data streams need not be as described in the specific embodiment, the precise function of some of the codes such as the status codes, not being a feature of the invention. Thus, for example, there is no need to include in each transmission from a vehicle the vehicle identity code since the master station apparatus "knows" which vehicle is transmitting at any instant since the master station controls the transmission. Thus the vehicle identity code may be replaced by a start code common to all the vehicles when transmitting to the master station. This code, of course, is different from the vehicle and beacon start codes. Again, although Figure 2 shows only ten stages for register 27, the full number of stages shown in Figure 1 may be provided. This not only standardizes the register for use on both vehicles and beacon stations, but may have the advantage that the number of bits in the data stream transmitted by the master station is the same in all cases.

WHAT WE CLAIM IS:—

1. A vehicle monitoring radio communication system including a fixed main radio transmitting/receiving station, a plurality of fixed beacon radio transmitting stations located in the transmission area covered by the main station, each beacon station being so located in said area and having such a transmission power that the region covered by its transmission does not overlap the transmission region of any other beacon station of the system; and at least one vehicle provided with radio receiving apparatus for receiving information transmitted by the main and beacon stations, with a store for storing information received from any beacon station, and with a radio transmitter for transmitting, a request by the main station, information including stored information received from any beacon station; wherein the system further includes control means operative such that the beacon stations transmit only during non-transmission periods of the main station and vice versa, and wherein the main and beacon station transmitters are arranged to transmit in the same carrier channel.

2. A system according to Claim 1 wherein said control means includes means at each beacon station responsive to receipt of a control signal from the main station to cause the beacon station to transmit its respective information.

3. A system according to Claim 2 wherein the main station includes means for transmitting said control signal as part of its transmitted information and wherein each beacon station is provided with a radio receiver, operating on said same carrier channel, for receiving the control signal and with a detector which detects the presence of the control signal in the received information and which as a result causes the beacon station transmitter to transmit the said beacon station information.

4. A system according to Claim 3 wherein each beacon station includes a store which stores a beacon identity code unique to that station, and means for transmitting the contents of said store as part of the beacon station information.

5. A system according to Claim 4 wherein each beacon station store includes means for storing a beacon calling code which calling code is common to all beacon stations, and wherein the or each vehicle includes means responsive to the receipt of said beacon calling code to cause the beacon identity code concerned to be stored in the vehicle store for subsequent retransmission to the main station.

6. A system according to any previous Claim wherein the or each vehicle is provided with a detector for detecting the presence of a vehicle identity code, unique to that vehicle, in received information, which detector then causes stored information received from any beacon

station to be automatically transmitted by the vehicle transmitter.

7. A system according to any previous Claim wherein each vehicle includes a visual display unit and means for decoding and displaying a message portion of information received from the fixed main station.

8. A system according to Claim 7 as dependent upon Claim 6, wherein said message portion is only decoded and displayed if the information received from the main station includes the vehicle identity code unique to the vehicle concerned.

9. A system according to any of Claims 6, 7 or 8 as dependent upon any of Claims 2 to 5, wherein the main station is provided with means for including, in the information it transmits, either any selected one of a plurality of vehicle identity codes each of which is unique to a particular vehicle or the said control signal.

10. A system according to any previous Claim wherein the or each vehicle is provided with means for storing in the vehicle store a code indicative of the distance travelled by that vehicle from a given location, whereby said distance code is included in the information transmitted by the vehicle transmitter.

11. A system according to Claim 10 wherein said given location is the location of that beacon station from which a transmission was last received by said vehicle.

12. A system according to Claim 11 wherein the said distance code is derived from a binary counter which progressively counts unit distances travelled by the vehicle.

13. A system according to Claim 12 including means for resetting said counter to a predetermined count value each time beacon station information is received.

14. A vehicle monitoring radio communication system substantially as hereinbefore described with reference to the accompanying drawings.

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1452029 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

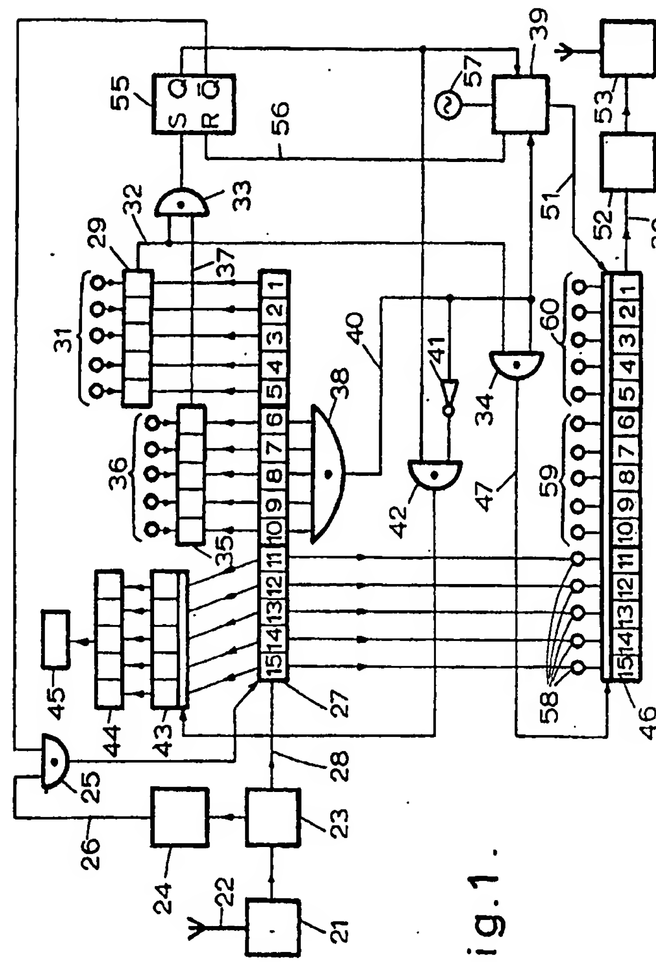

Fig.1.

1452029 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

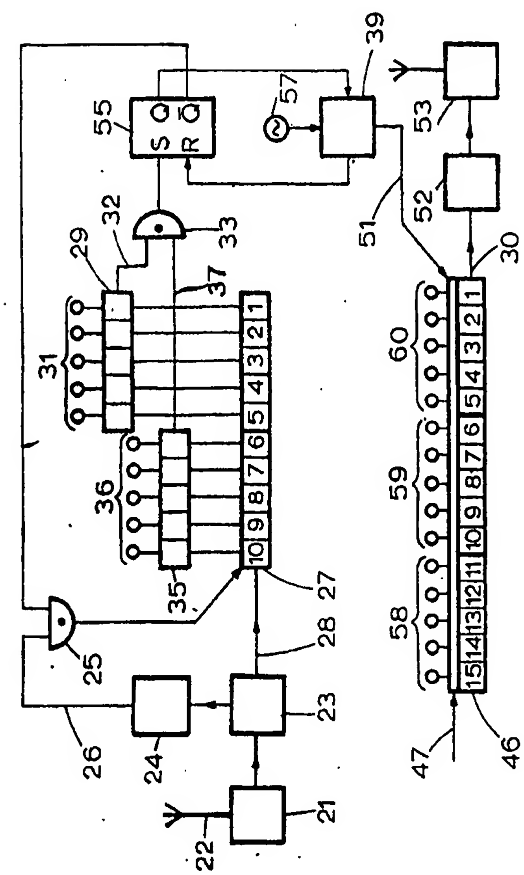

Fig. 2.

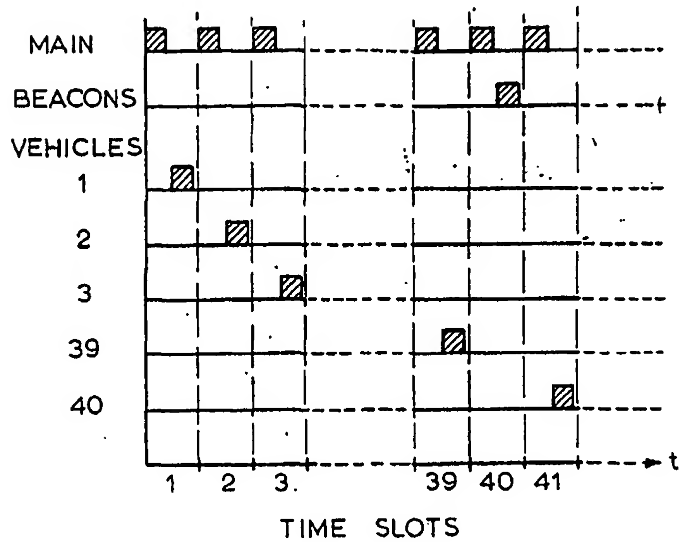

Fig.3.